

Climate change and developing countries

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This article takes stock of current knowledge of climate change and the response to this major problem affecting the environment and economic development. It begins with a brief review of climate change science and impacts as assessed by the Intergovernmental Panel on Climate Change. It then reports on the status of the United Nations Framework Convention on Climate Change and its Kyoto Protocol, and summarizes national commitments to making the effort required to mitigate climate change by limiting the emission of greenhouse gases. The main issues still to be addressed are identified, focusing in particular on carbon markets and adaptation funding. Future prospects are considered, including possible emissions targets for developing countries. The article thus focuses on the key issues of concern for developing countries.

What is the problem of climate change?

Human activities release greenhouse gases (GHGs) into the atmosphere. The principal gases involved are carbon dioxide (CO₂) from energy production and use and from deforestation, methane (CH₄), nitrous oxide (N₂O) from agriculture and land-use change, and three 'trace gases' or artificial chemicals, including halogenated hydrocarbons and sulphur hexafluoride (SF₆). The concentration of these gases in the atmosphere has already increased from about 275 ppmv (parts per million by volume) prior to the industrial revolution (up to the year 1750) to 368 ppmv in 2000,¹ an increase of 34%. Carbon that has been stored in the Earth's crust (in the form of oil, coal, and other fossil fuels) over millions of years is being released into the atmosphere relatively rapidly. According to the Intergovernmental Panel on Climate Change (IPCC), the Earth's mean surface temperature increased by about $0.6 \pm 0.2^\circ\text{C}$ during the twentieth century.

The certainty in separating the signal of anthropogenic influences from the 'noise' of natural climate variability has increased. The IPCC reviews the existing literature and publishes assessment reports summarizing the state of knowledge of climate change. Its Third Assessment Report evaluated the available evidence and concluded that 'there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities'.¹ The increased confidence compared with that for the second assessment (issued in 1996) was due in part to a longer and more closely scrutinized temperature record, new detection techniques, and model estimates for the last 50 years that are consistent with observations (for a fuller discussion, see ref. 1, pp. 10 ff.).

Rising levels of GHGs in the future are expected to continue to contribute to climate change. If emissions persist in rising, global temperatures are expected to increase between 1.4 and 5.8°C by the end of the 21st century.² This is two to 10 times more than the observed global warming in the last century; land areas are expected to warm more than oceans. Different scenarios for emissions are shaped by major drivers, in particular economic growth, demographic changes and technological innovation, as described in an IPCC Special Report on Emission Scenarios

(SRES).³ These changes are occurring at a relatively rapid rate in terms of geological time, very likely without precedent in the last 10 000 years.

Climate change is likely to have a significant impact on the global environment. In general, the faster the climate alters, the greater will be the risk of associated damage. Mean sea level is expected to rise 15–95 cm by 2100, causing flooding of low-lying areas and other devastation. Figure 1 shows the relationship between increasing temperatures (they differ according to the details of the emission scenarios) and reasons to be concerned about the consequences of climate change. The list of impacts is long, but a few examples will convey the scale of the problem: the viability of key ecosystems is put at risk by a temperature change of only 1–2°C, including those of coral reefs, arctic ecosystems, and coastal wetlands. The Greenland ice sheet, which contains sufficient water to raise sea levels by ~7 metres, would become unstable with a local warming of 3°C, and gradually lose its ice mass.⁴

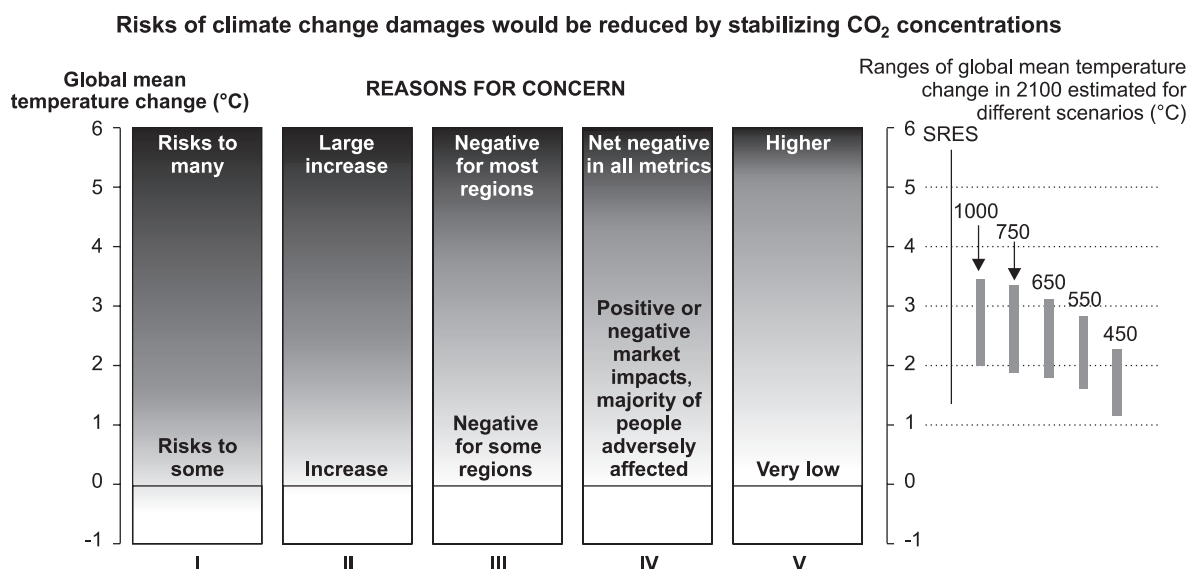
Who is responsible for the problem — and who has the capacity to act?

Regional impacts have been studied by the IPCC, which finds that poor countries and communities are most vulnerable to the consequences of climate change. This is because of their relatively high sensitivity to climate disruptions and limited capacity to adapt, and more limited resources with which to mitigate the impacts.⁵ Human society will face, and have to adapt to, new risks and pressures on food security, water resources, physical infrastructure and from extreme events — floods, droughts and severe storms.

The ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC), in Article 2, is to stabilize GHG concentrations at levels preventing dangerous climate change, while allowing ecosystems to adapt, ensuring food security and allowing sustainable economic development.⁶ This will require significant effort. Given an expanding global economy and growing populations, it demands substantially more efficient use of energy, a switch to cleaner sources of energy, and fundamental changes in other economic sectors. The IPCC's Second Assessment Report averred that 'immediate stabilization of the concentration of carbon dioxide at its present level could only be achieved through an immediate reduction in its emissions of 50–70% and further reductions thereafter'.⁷

By comparison, the Kyoto Protocol targets amount to emissions reductions of 5.2% from 1990 levels, and only for industrialized countries. What matters for climate change are cumulative emissions in the future — reductions that will be required this century are in the order of magnitude of 1100 to 1500 gigatonnes (Gt) of CO₂-equivalent (GtCO₂-eq), while the potential for mitigation ranges from 13.2 to 18.3 GtCO₂-eq per year.⁸ Clearly, there is a large gap between what is required to address the problem and the current commitments that have been negotiated in the international arena. The estimated size of the emissions 'gap' of Annex I parties (rich countries, excluding the United States and Australia) is expected to be approximately 275–880 MtCO₂-eq by 2010.⁹ As of April 2004, the mitigation effort of 77 projects under the Clean Development Mechanism (CDM) was

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I. Unique and threatened systems

Extinction of species.
Loss of unique habitats, coastal wetlands.
Bleaching and death of coral.

II. Extreme climate events

Health, property, and environmental impacts from increased frequency and intensity of some climate extremes.

III. Distribution of impacts

Cereal crop yield changes that vary from increases to decreases across regions but which are estimated to decrease in most tropical and subtropical regions.
Decrease in water availability in some water-stressed countries, increase in others.
Greater risks to health in developing countries than in developed countries.
Net market sector losses estimated for many developing countries, mixed effects estimated for developed countries up to a few degrees of warming and negative effects for greater warming.

IV. Global aggregate impacts

Estimates of globally aggregated net market sector impacts are positive and negative up to a few degrees of warming and negative for greater warming.
More people adversely affected than beneficially affected even for warming of less than a few degrees.

V. Large-scale, high-impact events

Significant slowing of thermohaline circulation possible by 2100.
Melting and collapse of ice sheets adding substantially to sea-level rise (very low likelihood before 2100; likelihood higher on multi-century time scale).

Fig. 1. Projected temperature changes and reasons for concern.²

130 MtCO₂-eq up to 2012 (www.cdmwatch.org/quick-stat/), although this does not count projects that have still to be introduced. More efforts at mitigation can be expected, but the level of effort needs to increase by an order of magnitude.

The goal of the UNFCCC is to stabilize GHG concentrations, under certain constraints. The convention recognizes that in achieving this task equity among nations is crucial, and it establishes the principle of 'common but differentiated responsibilities and respective capabilities' (Article 3.1). Since countries are the Parties to the Convention and the Protocol, some indicators of national level efforts made to control GHG emissions is appropriate. The Global Governance Initiative report to the World Economic Forum provided some useful, albeit imperfect, indicators for some leading countries (see Table 1), both industrialized and developing.¹⁰ The notion of responsibility is captured in relation to several indicators, while national income gives some sense of ability to mitigate. It also records the share of renewables and status in ratifying the Kyoto Protocol. The current and historical situation represented by these figures provides the historical context for considering future targets and scenarios (see below).

For this purpose, we turn first to a brief review of the status of the climate change negotiations.

Negotiations on climate change

The response of the international community to the problem of climate change is organized under the UNFCCC, adopted at the 1992 Rio Earth Summit and now includes 186 countries. As the name indicates, the FCCC is an institutional framework for a multilateral response to climate change. The highest decision-making body of the convention is the Conference of the Parties (COP). All states that have ratified or acceded to the convention are parties to the FCCC. The COP meets annually, with its two attendant bodies — the Subsidiary Body for Scientific and Technological Advice, and the Subsidiary Body for Implementation — meeting between sessions. The COP and subsidiary bodies are serviced by a secretariat. The COP can review existing commitments, as well as adopting new ones — such as those agreed under the Kyoto Protocol in 1997. While the convention includes commitments, these are not binding.

Under the convention, both rich and poor countries accept

Table 1. Indicators of responsibility by countries.^{10,42}

Country	Responsibility/emissions				
	Contribution to the global CO ₂ concentration increase (1950–2000) (%)	Change in CO ₂ emissions (1990–2000) (%)	Emissions per capita (tons of C equiv. 2000, all gases)	Carbon intensity (tons of C per \$GDP-PPP, 2000)	Change in carbon intensity (1990–2000) (%)
Australia	1	26	6.6	193	–11.4
Canada	2	22	6.0	172	–7.8
EU	17	0	2.9	99	–18.1
Japan	5	12	2.8	104	–2.4
Russia	9	–32	3.8	427	2.6
U.S.	26	18	6.6	162	–14.5
China	10	39	1.1	201	–46.8
Brazil	1	53	1.8	73	17.6
India	3	64	0.5	99	–3.6
South Korea	1	85	3.0	185	2.1
Mexico	1	25	1.5	125	–11.3
South Africa	1	17	2.6	200	–1.7
World	100	14	1.6	147	–13.1

Country	Capability	Renewables	Status in negotiations	Submission of national communication
	GDP per capita (\$PPP, 2000)	Share of renewables in electricity mix (2000) (%)	Kyoto Protocol ratification	
Australia	25 693	9	No	Yes
Canada	27 840	61	Yes	Yes
EU	23 645	15	Yes	Yes
Japan	26 755	10	Yes	Yes
Russia	8 406	19	Yes	Yes
U.S.	34 142	9	No	Yes
China	3 976	17	Yes	No
Brazil	7 604	90	Yes	No
India	2 358	14	Yes	No
South Korea	17 470	2	Yes	Yes
Mexico	8 985	19	Yes	Yes
South Africa	9 466	1	Yes	No
World	7 295	18.7		

commitments to submit 'national communications' including GHG inventories. They agree to adopt national programmes for mitigation and adaptation. Technology transfer is another broad commitment. All parties agree to take climate change into account in policy-making and planning, to cooperate on scientific matters, and to promote education and the exchange of information. It is recognized that implementation of commitments by developing countries will depend on financial and technical assistance from the rich nations.¹¹

Developed countries (Annex I Parties to the Convention) have more specific commitments under Article 4.2 of the convention. For instance, there is a commitment for these nations to take measures aimed at returning their emissions to 1990 levels by the year 2000 in FCCC Article 4.2.b (this was not achieved by many countries — the notable exception was the former Soviet Union, where emissions declined owing to economic stagnation rather than climate policy¹⁰). The richest countries (Annex II, essentially the OECD states), agree to provide 'new and additional financial resources' and facilitate technology transfer. Annex II countries pay the 'agreed full cost' of non-Annex I (NAI) national communications under Article 4.3. They also help fund the transfer of environmentally sound technologies, particularly for the benefit of developing countries.

Specific mitigation commitments for industrialized countries were negotiated and included in the Kyoto Protocol. The parties to the convention have agreed by consensus that developed countries will have a legally binding commitment to reduce their collective emissions of six GHGs by at least 5% compared with 1990 levels during the period 2008–12. The protocol establishes three 'flexible mechanisms': an emissions trading regime which allows assigned amounts to be traded under Article 17; Joint

Implementation (JI) — a project-based mechanism involving Annex I parties under Article 6; and the Clean Development Mechanism, which allows investment by Annex I parties in projects in developing countries under Article 12. These mechanisms assist Annex I parties in achieving their emission reductions at least cost. The CDM includes a second objective of assisting developing countries in achieving sustainable development.

The convention and protocol already embrace many commitments on adaptation. All parties to the convention have agreed that 'the specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change 'should be given full consideration' (Article 3.2). While all parties are to cooperate in general adaptation activities, the commitment to 'agreed full costs' includes development of national vulnerability and adaptation assessments and incremental costs for adaptation technologies.

Although the focus of the Kyoto Protocol is on establishing targets for GHG reductions and mechanisms for achieving it, it is also structured to assist in generating funding to address adaptation needs. Parties to the protocol have agreed, in Article 12.8, 'to ensure that a share of the proceeds from certified [CDM] project activities is used to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation'. With the setting up of the Adaptation Fund (see below), a 2% share of proceeds from CDM project revenue will contribute to adaptation funding.

The Kyoto Protocol entered into force on 16 February 2005, ninety days after Russia ratified it. Russian ratification was crucial in the absence of the United States, adding another 17.4% of Annex I emissions required to bring the protocol into force.

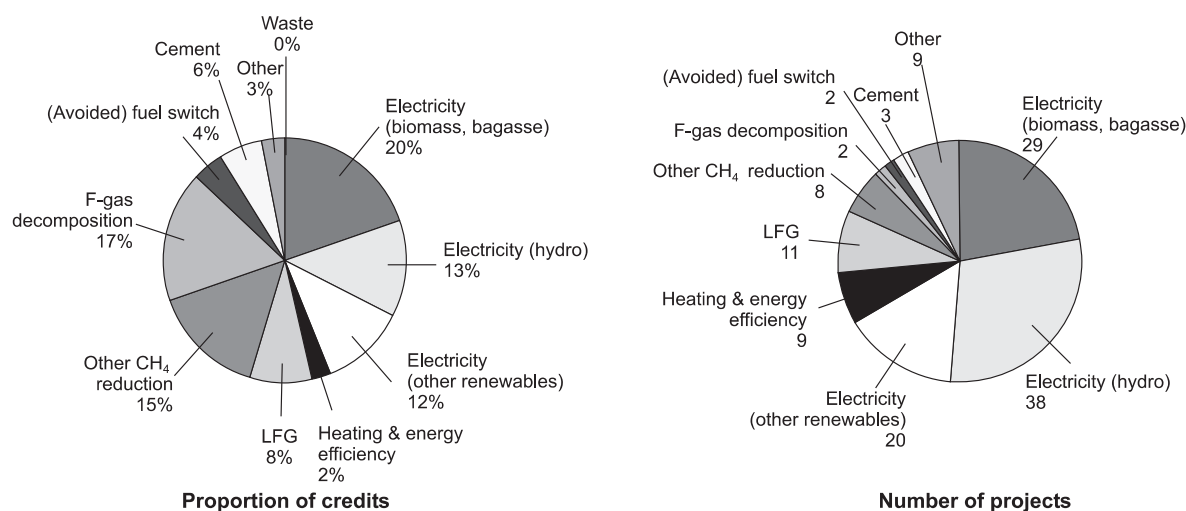


Fig. 2. The Clean Development Mechanism (CDM) portfolio, showing the relative importance of the different sectors.¹⁴ Source: project documentation.

Multilateral environmental agreements not only require signature by delegates to a conference, but also ratification by national processes. In the case of the Kyoto Protocol, the conditions for the instrument to enter into force were that it needed to be signed and ratified by 55 countries, with total emissions accounting for 55% of the CO₂ emissions from Annex I countries in the year 1990. The emissions (CO₂ only) for the base year (mostly 1990) are listed in Annex B of the protocol — mostly the same parties as Annex I to the UNFCCC. Many developing countries ratified early, satisfying the condition regarding the number of ratifying countries. Progress towards the second condition, regarding total emissions, was made by ratification by the European Union (and its members), Japan, Canada and a few other industrialized countries. Notably absent are the United States and Australia, although they remain parties to the conventions.

The U.S. made clear in March 2001 that it did not intend ratifying the protocol, and Australia is also unlikely to change its position. The U.S. alone accounted for 36.1% of emissions in Annex B (and about 24% of global CO₂ emissions, and 16% of all GHGs in 2000). In part, the withdrawal of the U.S. consolidated the political will of the rest of the world to go ahead and complete the Marrakech Accords (at the COP-7 meeting in 2001). The climate strategy of the Bush administration is to 'reduce' emissions intensity (GHG/GDP) by 18% until 2012. This target is almost identical to the 17% actual reduction in the 1990s. The proposed *relative* target would permit an increase in *absolute* emissions for the largest emitter due to economic growth, estimated at an overall increase in emissions of about 30% by 2012 compared to 1990. Internationally, the U.S. actively pursues bilateral negotiations, including with major developing countries, to promote cleaner and more efficient technologies (www.state.gov/g/oes/climate/).

Russia played a long end-game before finally ratifying the Kyoto Protocol. Participation in the flexible mechanisms was financially attractive, but various departments within the Russian administration differed in their views on the advantages of ratification. Russian representatives at the World Summit on Sustainable Development in 2002, and on several other occasions, indicated that Russia would ratify. It appeared that concessions related to negotiations under the World Trade Organisation (WTO) were important in finally persuading the Duma and the Russian president formally to ratify.

The entry into force of the Kyoto Protocol had several implications. Politically, it represented a victory for multilateral negotia-

tions, despite the unilateralism shown by the United States.¹² In legal terms, the protocol is the first multilateral environmental agreement with a binding compliance system — in other words, if Annex I parties do not meet their targets, there are legally binding consequences. Another legal implication of entry into force of the Kyoto Protocol was the beginning of the round of Meetings of the Parties (MOP) together with the UNFCCC COP — with the U.S. and Australia parties to the latter but not the former. The first 'COP/MOP' will be held in Montreal, Canada, from 28 November to 9 December 2005.¹³ The formalization of the protocol firmly established carbon markets under the protocol's 'flexible mechanisms', with a noticeable upward impact on carbon prices after the announcement of Russian ratification.

Projects, markets and finances

The Clean Development Mechanism

The CDM is another major development in carbon markets, with about \$800 million* invested so far. The CDM emerging portfolio has the largest share of credits from the decomposition of fluorine-containing gases [based on hydrofluorocarbons, 17% of Certified Emission Reductions (CERs)] and landfill gas projects (23%). The single hydrofluorocarbon project is boosted by the relatively high global warming potential of fluorinated gases, whereas methane capture is the subject of several projects. Measured by the number of projects, hydro-electricity is the most popular project type, but the potential emission reductions per project are relatively low (see Fig. 2).

Any lessons drawn from the CDM portfolio must be tempered by recognition that the mechanism is only just emerging. Its structure may well change, influenced by the maturing of the CDM institutions themselves, competition from JI projects and assigned amounts, the influence of the European Emissions Trading System and its link to the CDM and other factors.

Most of the allocated investments (worth \$800 million) in CDM projects or purchases of CERs have been from public funds.¹⁴ There is a leveraging effect in that total project investment is higher than the fund contribution — so overall investment in actual projects should be about 6 to 8 times the \$800 million.¹⁵ Total project investment can be expected to increase over time, including more contributions from the private sector.

In the bigger context of international financial flows, total overseas development aid in 2002 was \$61.9 billion and direct investment \$49.8 billion, according to the OECD. This invest-

*In this article, financial amounts are quoted in U.S. dollars (\$) and euros (€).

Table 2. Major CDM investment allocations.¹⁴

Scheme	Coverage	Involvement	Amount
Austria	JI/CDM	Austrian government	€72m (2003–06)
BioCarbon Fund	CDM/JI	Interest from governments (e.g. Canada) and companies.	\$30–50m
Community Development Carbon Fund	CDM	4 governments (Austria, Canada, Italy, Netherlands), 7 companies (Japanese, German, Spanish, Swiss)	\$40–70m
CERUPT	CDM	Dutch government	€32.5m
Denmark	JI/CDM	Danish government	€120m to 2007
Finland	CDM/JI	Finnish government	€10m
Germany	JI/CDM	KfW (Federal government and states)	€25m (to €50m)
INCaF	CDM	Dutch government	€44m
Italian Carbon Fund	JI/CDM	Italian government (also open to contributions from Italian companies)	\$20m (target \$80m)
Japan Carbon Fund	CDM/JI	JBIC (Japan Bank for International Cooperation) and DBJ (Development Bank of Japan)	€31.3m + €23.5m
NCDF	CDM	Dutch government	\$120–160m (32 Mt CO ₂ -eq.)
PCF	JI/CDM	6 governments (Canada, Finland, Netherlands, Norway, Sweden, Japan Bank for International Cooperation) and 17 companies	\$180m

ment in climate change amelioration is thus much smaller. More specifically, in the energy sector the World Energy Investment Outlook recently estimated that \$16 trillion would be needed in energy supply infrastructure between 2001 and 2030.¹⁶ Of this, 60%, or \$10 000 billion, is expected to be invested in the power sector and a further 19% in oil and gas. Almost half of the total investment is expected to be required in developing countries.

Initial investment allocations to the CDM were led by the World Bank's Prototype Carbon Fund (PCF) and the Dutch CERUPT tender, but several more funds have been established. Climate-related funds are supported mostly by governments or intergovernmental organizations (Table 2).

Mitigation funding through the GEF

Funding for mitigation projects in poor countries also flows through the financial mechanism of the UNFCCC, which is effectively the Global Environment Facility (GEF). The GEF was formed in the lead-up to the Rio Earth Summit in 1992, to respond to the needs of various environmental conventions for a financial mechanism. It is the main channel of funding for developing countries under the UNFCCC. There are three implementing agencies: the UN Environment Programme, the UN Development Programme, and the World Bank. A legal instrument governs the GEF, and a memorandum of agreement between the GEF Council and the COP was drawn up at the COP-1 meeting. The GEF Council — with 16 members from developing countries, 14 from rich countries and two from economies in transition — develops, adopts and evaluates programmes. The role of the GEF in supporting the convention as a financial mechanism is unique. It is accountable to the COP, which reviews the mechanism every four years. Rich countries are to provide the 'agreed full incremental costs' of items in Protocol Article 10, which include both mitigation and adaptation programmes.

The GEF's programmes are focused specifically on climate change. The vast majority of GEF climate change funding of \$1.5 billion has supported mitigation projects.¹⁷ The overall funding for the GEF has been as follows (dates in brackets, followed by total amounts pledged): for the pilot phase (1990–94) \$1.13 billion; First Replenishment (1995–98) \$2 billion; Second Replenishment (1998–2002) \$2.75 billion; and Third Replenishment (2002–06) \$3 billion. Each of the four operational programmes relates to mitigation — energy efficiency, renewable energy, sustainable transport, and reduction of cost of low-GHG-emitting technologies. Figure 3 shows the breakdown of spending in major areas in 2002, including enabling activities. The six strategic priorities have also been focused on mitigation

— transformation of markets for high-volume, commercial low-GHG products or processes; power sector policy frameworks supporting renewable energy and energy efficiency, increased access to local sources of financing; global market aggregation and national innovation for emerging technologies; and modal shifts in urban transport and clean vehicle/fuel technologies. A seventh strategic priority on adaptation was added at COP-9 in Milan.

The scale of investment is comparable with the CDM, but smaller than development funding or foreign direct investment. The size of the funding nevertheless has the potential to leverage other investments, through co-financing, by a factor of four.¹⁸ An example is the 'Five Million Fund' administered by the GEF, which provides reliable financing to leverage private investment for renewable energy in remote locations. The fund aims to link climate protection and poverty reduction, providing five million households with renewable energy through a partnership approach. The usual modus operandi of GEF has been subsidizing investment costs for renewable energy projects, but it has also tested a range of new approaches to financing. These include contingent grants, revolving funds, private equity approaches, loans and guarantees.¹⁹ Such approaches play an important role in mobilizing private investment.

Other experience with mitigation programmes

Mitigation does not occur only through carbon markets, the CDM and the GEF. A wide range of actors — Kyoto parties, U.S.

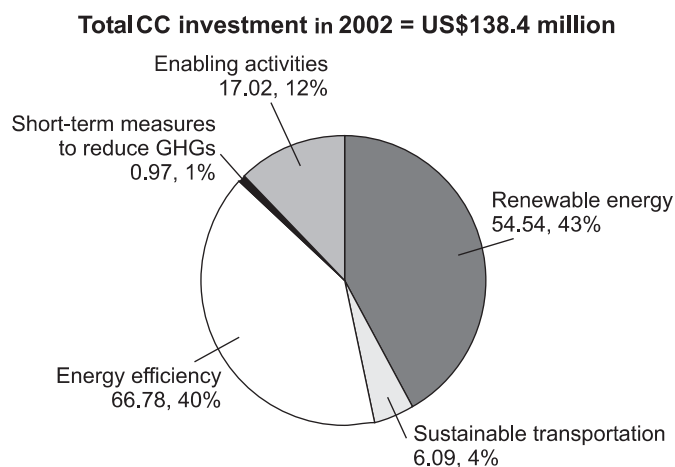


Fig. 3. Investments in climate change through the Global Environment Facility (GEF) (2002). The first number refers to the investment in \$million, the second indicates the share of total investment.

states, individual companies, brokers and international financial institutions — are becoming involved in mitigation programmes.

Prior to the Marrakech Accords, parties to the convention piloted mitigation programmes under the notion of 'Activities Implemented Jointly' (AIJ). Initiated at COP-1 in 1995, this pilot phase explicitly did not award carbon credits, and included both developing countries and economies in transition. The main aim was to gain experience with mitigation projects, and more than 150 projects were registered in over 40 countries (see <http://unfccc.int/issues/aij.html>). The future of these pilot projects remains unclear. The U.S. launched its own (IJI) programme as part of AIJ in 1993. The last round of projects was approved in 2000. Some 50 mitigation projects were funded under this programme (see www.usiji.gov).

Among Kyoto parties, early movers in the CDM have included the Dutch government through ERUPT (JI) and CERUPT (CDM) and the World Bank through the Prototype Carbon Fund. Some of these funds aim at particular niches. For instance, the Community Development Carbon Fund targets small-scale mitigation projects that also improve the livelihoods of local communities, and the BioCarbon Fund supports mitigation projects combined with environmental benefit, adaptation and poverty reduction (see <http://carbonfinance.org/cdcf/home.cfm> and <http://carbonfinance.org/biocarbon/home.cfm>). Investment by early movers in the CDM is at least in part intended to influence the future market by setting *de facto* technical standards and occupying market position.²⁰

Joint Implementation under Article 6 of the protocol allows investment in projects in countries with economies in transition. The fundamental difference from the CDM is that, in this case, both countries have caps on their national emissions under Kyoto. The overall limitations mean that any errors in estimating real emission reductions at the project level would reflect in the national GHG registries (in so far as these are accurate).

Developing countries, while not formally required to meet quantified mitigation targets, are taking significant action.^{21,22} Emissions intensity in China has decreased considerably in recent years, almost 50% since 1990,¹⁰ partly in order to save scarce energy and partly to reduce local air pollution. Policies have included a reduction in coal and oil subsidies between 1990 and 1995. China has also introduced tax incentives for constructing energy-efficient buildings, and now requires that all industrial boilers co-generate electricity with their waste heat. India has developed a domestic wind industry and has in the past provided leadership in the climate negotiations.

National programmes have been established to pilot mitigation projects. Canada ran a GHG Emissions Reduction Trading pilot programme throughout the country from 1998 to 2002. Ten project proposals were reviewed in a multi-stakeholder process and five were registered for trade. The programme established mandatory review criteria and drew lessons from the experience in a detailed report (see www.gert.org). Lessons included that 'policy decision and rules are required' on technical issues to ensure effective trading programmes.

Regional governments are also engaging in climate mitigation. Oregon and Washington states have established a CO₂ Standard and Climate Trust. Under the trust, new electricity generation sources must meet a CO₂ standard. Beyond a threshold of 0.675 lbCO₂/kWh, developers must either purchase project-based credits directly to offset their commitments, or pay a fixed fee to the trust. So far, over \$5 million has been invested via Climate Trust (www.energy.state.or.us/siting/rules.htm; www.climatetrust.org), which has undertaken two rounds of public solicitation of offsets, already contracting

2.5 MtCO₂ over 20 years.²⁰

There is substantial experience in U.S. states with programmes that focus on reducing local air, water and other pollution, with the (uncredited) co-benefit of reducing GHG emissions. These include Emissions Reduction Credit trading under the Clean Air Act, which allows projects at existing emissions sources to help new sources meet emission standards for criteria pollutants. Similarly, the discrete emission reduction programme operates in six U.S. states to enable compliance with state implementation plans for air pollution. The California South Coast Air Quality Management District established a Regional Clean Air Incentives Market for large point sources of NO_x and SO_x, and allowed projects to claim retrospective credits for emission reductions already achieved at non-controlled sources.

The city of Seattle has established a GHG Target and Offset Program, also known as Seattle City Lights. The target is net zero electricity supply. Project-based credits can be purchased from any location, although Washington State is preferred, and the expectation is that 400 000 tCO₂ per year will be purchased (http://seattle.gov/light/News/RFI_RFP/RFP_ggm.asp).

The Chicago Climate Exchange (CCX) has set voluntary targets for participants. There is a limited role for offsets in North America, but foreign locations for projects (in addition to the U.S.) are permitted, including Brazil and Canada. The CCX was scheduled to start in 2003 and run until 2006 (www.chicagoclimateexchange.com).

More forward-looking companies are implementing voluntary GHG emission reduction plans; for example, some motor companies have increased their sales of hybrid vehicles. European companies need to meet regulations under the ETS and thus are taking GHG emissions into account in their investment strategies. Companies including TransAlta, a major coal-based electricity producer in Canada, have set targets and begun acquiring carbon credits as a learning and risk management strategy in anticipation of future regulation. Emissions brokers and project developers like CO2e.com, Natsource, Econergy, and various accounting and engineering firms have also developing funds, and pooled approaches to building project-based mitigation portfolios.²⁰

Many non-governmental organizations (NGOs) in both industrialized and developing countries are committed to promoting action on climate change. They provide information, analysis and advocacy.

In addition to investment in mitigation projects, significant work has been undertaken in establishing effective standards, registries and reporting systems. The World Resources Institute and the World Business Council on Sustainable Development have established a GHG Protocol (www.ghgprotocol.org). Since developing its widely used Corporate GHG Accounting and Reporting Standards for organizational inventories, they are nearing completion of their first standards and guidelines document for project-based mitigation activities. The environmental NGO sector has produced a CDM gold standard to ensure a higher quality of mitigation projects from the point of view of sustainable development (www.panda.org/downloads/climate_change/thegoldstandardoverview.doc). Other standards include NESCAUM (www.nescaum.org/Greenhouse/Registry/state_matrix.html) and the Climate Registry (www.climateregistry.org/).

Carbon markets: EU emission trading system

A key development in carbon markets is the European Emissions Trading System (ETS). It is effectively a cap-and-trade device to limit CO₂ emissions from large industrial sources. The

sectors covered are electricity (all fossil fuel generators over 20 MW), oil refining, cement production, iron and steel manufacture, glass and ceramics, and paper and pulp production. Sectors will be reviewed in 2006 and smaller installations can 'opt in' from 2005–07. Targets must be in line with European countries' domestic implementation of Kyoto commitments.²⁴

Central to the implementation of the ETS are national allocation plans, to be developed by March 2004. These plans will set targets for the relevant sectors and allocate allowances (each worth one tonne of CO₂), effectively setting absolute emission caps for installations for the relevant periods. There will be penalties for non-compliance. These allowances will be tradable, and a 'linking directive' will allow units from CDM and JI projects (subject to some conditions) to be substituted for allowances.

The ETS will create significant financial flows, representing the major carbon market before emissions trading under the Kyoto Protocol starts from 2008. As a major carbon market, the ETS might play an important role in a climate regime after 2012 (the end of the first commitment period under the Kyoto Protocol). It brought together a 'Friends of Kyoto' group — which could include a broad range of developing countries, and major industrialized ones (the enlarged EU, Canada, Japan, Norway, Switzerland, and New Zealand). The ETS also will recognize credits from emissions trading schemes set up elsewhere, specifically mentioning the U.S. states of California and Oregon.²⁵ Proposals to combine emissions trading markets might be more attractive to the U.S. than joining Kyoto.²⁶ The process of consolidating markets could happen on a bilateral basis, separate from the UNFCCC process.²⁵ Each country would have to set a domestic limit before becoming eligible to join the larger market — that is, no trade without a cap.²⁸

Adaptation funding

Financial flows for adaptation do not take the form of carbon markets, but are channelled through funds administered by the GEF. The earliest guidance given to the GEF, at COP 1 in Berlin, provided for a staged approach to adaptation. In this decision, the financial mechanism was asked to consider criteria for supporting planning and studies of climate-change impacts under the first stage. The second stage progresses onto measures to prepare for adaptation. The third and most advanced stage is concerned with measures to facilitate adaptation.

At COP-7, parties agreed there was a need for new and additional funding beyond contributions which are allocated to the climate change focal area of the GEF and to multilateral and bilateral funding for the implementation of the convention. The scope of activities eligible for funding was also included. The Least Developed Country (LDC) Trust Fund and Special Climate Change Fund (SCCF) were established under the convention, and the Adaptation Fund under the protocol. All three funds are to be operated by the GEF on the basis that each fund remains distinct from the existing GEF Trust Fund used for climate change activities, which shall remain in operation.

Many assessment and planning activities have already been funded by the GEF, and the challenge is to define concrete implementation activities. Significant progress has been made, notably in prioritizing adaptation activities through a participatory process of the National Adaptation Programme of Action by LDCs. Under the LDC Trust Fund, the GEF has provided \$200 000 per country. Preliminary results are expected from 2005 onwards.

COP-7 agreed to establish the Special Climate Change Fund

under the convention to finance adaptation, technology transfer, projects in a number of sectors (transport, industry, agriculture, forestry, and waste management); and 'activities to assist developing country parties referred to under Article 4.8 (h) in diversifying their economies'. COP-8 advocated that this funding should be complementary to other funds administered by the GEF.

The Adaptation Fund operates under the protocol, and will receive guidance from the COP/MOP once the protocol enters into force, but until then from the COP. It will be financed by a share (2%) of the proceeds from CDM projects as well as other sources.

In response to guidance from COP-7, the GEF council approved in November 2003 a seventh strategic priority on adaptation, 'Piloting an operational approach to adaptation', within the GEF Trust Fund. The scheme is limited to pilot projects worth \$50 million during 2005–07. Pilots should show how adaptation planning and assessment can be practically translated into projects that will provide real benefits. Full costs are to be paid only for small grants, while large and medium projects will require co-financing. The pilot began in July 2004 and will end when the LDC and Special Climate Change Funds start. Adaptation has precedence in both these funds, with COP 9 providing guidance to the GEF for the operation of the Special Climate Change Fund, prioritizing adaptation and technology transfer.

A paper on 'assistance to address adaptation' for the GEF Council in May 2004 indicates that adaptation activities must be country-driven and integrated into national sustainable development planning and poverty-reduction strategies.²⁹ It links local adaptation to GEF's mandate in that the 'need to adapt to adverse impacts of climate change is an incremental burden to developing countries, generated by a global environmental impact'. Capacity building can be incremental and targeted, and also have 'a global dimension as they help vulnerable countries and communities to address the global environmental impact of climate change'.²⁹

Key issues for the future: Sustainable development, mitigation and adaptation

Mitigation

The discussions on mitigation within the UNFCCC negotiations have evolved over time. Much of the early discussions were influenced by concerns about 'energy for sustainable development'.³⁰ In terms of demonstrating technologies, the focus was often on renewable energy and energy efficiency.³¹ The operational programmes (OPs 5 and 6) of the GEF reflect this focus. In the negotiations, however, the exclusion of specific technologies was resisted. 'Negative lists' of technologies to be excluded — for instance, cleaner coal or nuclear energy technologies — were not endorsed in COP decisions, nor were 'positive lists' of renewables and efficiency. It was not seen as government's role, individually or in multi-lateral negotiations, to pick technology winners, and the literature supported investigation of different technologies and policies.³² The IPCC reviews key developments in the knowledge around technological options to mitigate GHG emissions.^{8,28}

Recent discussions of mitigation efforts in developing countries have often been focused on the CDM (see below). While clearly an important mechanism, sustainable development is at least as important an approach to mitigation. The debates on climate change mitigation and sustainable development have been linked, in particular with the realization that a significant

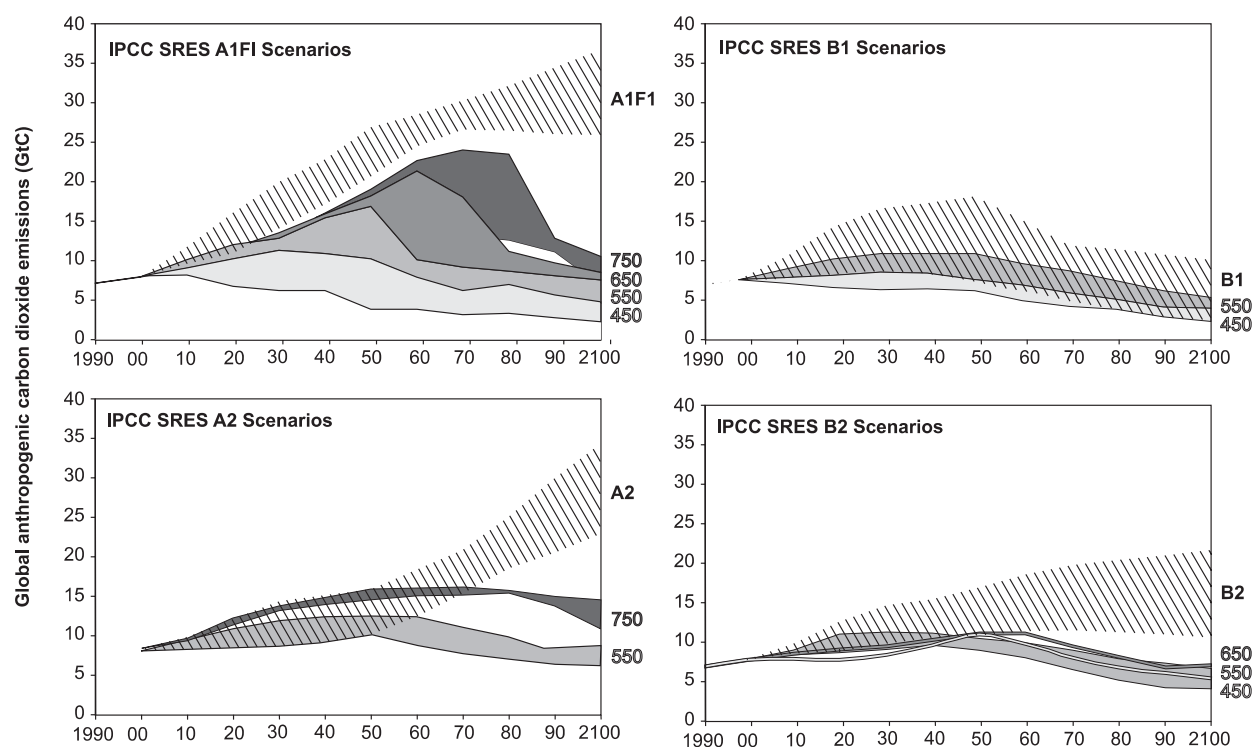


Fig. 4. Comparison of reference emissions scenarios (without climate policy) and climate change mitigation scenarios. IPCC, Intergovernmental Panel on Climate Change; SRES, *Special Report on Emissions Scenarios* of the IPCC.

mitigation effort was already in place in developing countries. More would be needed in future by 'promoting development while limiting greenhouse gas emissions'.³³

Choosing a more sustainable development path means that the baseline — or reference — GHG emissions are lower than in other possible futures. The IPCC's Third Assessment Report found that this choice of future 'world' was more important than the drivers determining GHG emissions.⁸ Beginning with one or more future development ambitions, it would be possible to describe paths towards those goals.^{8,34} The SRES reference scenarios shown in Fig. 4 do not include any climate policy and are shown together with mitigation scenarios resulting in atmospheric concentrations of CO₂ ranging from 450 to 750 ppmv. The selected scenarios show clearly that the gap between the shaded reference path and the various (solid) stabilization paths is smaller in some cases. In other words, to reach the same atmospheric concentrations, significantly less effort is required for development paths where reference emissions are low (in the B family) than if the future world had higher emissions (in the A scenarios). The implication is that there are significant synergies between climate and non-climate policies.⁸

However, shifting development paths requires transitions in larger systems, not least energy economies.³⁵ This broader approach to mitigation links back to 'energy for sustainable development' and informs the debate about future mitigation commitments of developing countries. The prospects for a future round on quantified mitigation commitments are not on the official agenda, but increasingly are discussed by research organizations.^{36,37} With a review of 'demonstrable progress' due in 2005 (under Protocol Article 3.2), these discussions may become formal in the next few years.

The broader challenges of mitigation in developing countries keeps raising the question of whether the focus of efforts should be on climate change or sustainable development.³⁸ Greater capacity for adaptation is also enhanced by sustainable development.

Adaptation: funding, mainstreaming, implementation

The core mandate of the GEF has been to fund the incremental costs of global environmental benefits. The benefits of mitigation are clearly global, since everyone benefits from reduced emissions irrespective of where mitigation takes place. The consequences of climate change will vary from place to place, and the ability of poor communities to respond is the least, making them most vulnerable.⁵ Some of the impacts of climate change can be reduced by taking preventative action, but these depend on location. Increasing the capacity to adapt has significant co-benefits, but again these are largely local. The *causes* — emissions leading to increased concentrations to climate impacts — are global.³⁹ The local nature of adaptation is at a different geographical scale from the mandate for global environmental benefits.⁴⁰

Both adaptation and mitigation do not occur as discrete activities but often arise as part of ongoing activities. Countries anyway take measures to cope with natural climate variability, and are continually investing in activities (such as energy supply) that may emit more or less GHGs.

Analysis therefore is most realistic when it recognizes that many adaptation and mitigation options involve adjusting the orientation of ongoing investment and other activities ('mainstreaming'), rather than being discrete actions with easily separated costs and benefits.⁴¹ The incremental benefits of adaptation are often not as clear as for mitigation projects, with many activities simply requiring better development planning. For example, adaptation might mean taking new flood lines into account in planning housing, or modifying water resource planning to take into account increased climate variability. These activities already happen and are best supported by integrated development planning.⁴²

As adaptation activities can be capital-intensive and the benefits highly localized and immediate, the real challenge will be the development of secure, adequate and predictable funding to meet priorities, as well as equitable frameworks to

access this funding. Apart from funds, tiered national and regional insurance schemes have been proposed. They form part of an approach that emphasizes managing and spreading the risk to developing countries of climate effects such as extreme weather events, aiding recovery efforts and contributing to sustainable development.

Prospects for the future: How might future emissions targets be set?

Despite all these efforts, global emissions continue to increase. They rose by 14% between 1990 and 2000⁴³ — and have continued to rise ever since — even with the economic contraction and corresponding reduced emissions from Russia and other countries of the former Soviet Union, and in spite of the adoption of international agreements on climate change. While the current rate of emissions increase may be slightly slower than 'business as usual', it is a barely marginal improvement. Voluntary actions are not sufficient to deal with the scale of the problem, which needs profound changes to current practices. Addressing climate change effectively requires major transformations in the way we produce and consume energy.

Along with an emissions trading regime and the CDM, the Kyoto Protocol set quantified and binding emission reduction and limitation targets for Annex B countries, starting with a first commitment period of 2008–12. Industrialized countries have contributed most to GHG emissions over time. This is recognized in the convention's first stated principle in Article 3.1, requiring the rich countries to take the lead in combating climate change and its adverse effects.⁶ Hence, the Kyoto Protocol quantified emissions reduction targets only for Annex I (under the convention, or Annex B, under the protocol) parties. Clearly, annual emissions from developing countries (non-Annex I, hereafter NAI) are increasing. According to the World Resources Institute, CO₂ emissions from fuel combustion in poor countries increased 38.9% between 1990 and 2000, resulting in a share of 40% of annual global emissions in 2000.⁴³ Carbon dioxide emissions per capita were 11.9 t for Annex I and 2.0 t for NAI countries in 2000.

Future emissions and 'cross-over' dates (when NAI emissions will exceed those from Annex I countries as a group) are highly sensitive to the assumed emissions scenario³ and on the basis and units of comparison. Cross-over will occur relatively soon if one considers annual CO₂ emissions; if the analysis is based on temperature increase, cross-over comes much later. Annex I countries emit primarily CO₂, while developing economies with large agricultural and forestry sectors can be expected to have a higher share of methane and nitrous oxide in their totals — hence it matters which gases are included. The different years of convergence are apparent from the following quotations:⁴⁴

The moment of convergence between the Annex I and non-Annex I regions shifts from 2065 for only fossil-fuel CO₂ emissions to 2055 for all anthropogenic CO₂ emissions and, finally, to 2030 for all anthropogenic greenhouse gas emissions (page 57).

By using a modeling framework, we have shown that for a central reference case the moment of convergence of contribution of Annex I and non-Annex I is delayed from 2015, for anthropogenic CO₂ emissions, to 2045, for CO₂ concentration, and, finally, to 2055 for temperature increase (page 63).

Including land-use related CO₂ emissions and non-CO₂ emissions in calculating regional contributions to temperature change sharply increases the share of non-Annex I in temperature increase. However, the range of outcomes covered by the cases 'only fossil fuel CO₂ emissions' and 'all greenhouse gas emissions' decreases in future, because of the increasing dominating effect of the fossil fuel CO₂ emissions in the overall CO₂-equivalent emissions (page 65).

Whatever analytical approach is taken, it is clear that the contribution of developing countries *as a group* will constitute a growing share in future. It is equally evident that the responsibility of the rich nations will remain higher for a long time to come, if the analysis is on a per capita basis — critical if the analysis is to be fair,⁴ or considers cumulative emissions, which are the ones that matter most to the climate.⁸

Maintaining the established FCCC principle that developed countries take the lead, deeper cuts in emissions by all Annex I countries will be required in future.^{37/46} Annex II commitments under the convention and protocol to assist developing countries financially will also continue. Indeed, as the need for quantified mitigation targets in the more rapidly industrializing developing countries grows, the requirements for funding will increase.

Further differentiation between poor countries will probably be needed.^{37/46/47} NAI nations will expect Annex I states to take the lead, but not all the former can be expected to follow in the same way. Rapidly industrializing developing countries have some capability of limiting or even reducing their emissions, if their income and economic levels are an approximate guide. The most advanced of these, the 'newly industrialized countries', have the same average Human Development Index as economies in transition, and an average GDP per capita of \$10 700 compared to \$7 160 for the latter.³⁶

For LDCs, by contrast, measures of responsibility for climate change are very low — their total emissions of energy-related CO₂ accounted for less than 0.5% of the global total in 2000.⁴³ These countries' focus is primarily on adaptation to the impacts of climate change.

Given the absence of the U.S. and Australia from the Kyoto Protocol, initiatives outside of the formal UN process have explored a range of alternatives. While the Kyoto Protocol has entered into force, targets have been set only for Annex I countries, and only for the first commitment period from 2008 to 2012. The next round of 'post-2012' negotiations will start in 2005, as Article 3.9 of the protocol requires negotiations for new Annex I commitments to start seven years before the end of the first commitment period.⁴⁷ Politically, Annex I countries will exert pressure on developing countries also to engage in mitigation — in particular some of the larger emitters such as China, India, Brazil and South Africa.

Of significance for our continent is that the British prime minister, Tony Blair, has made climate change and Africa key themes of the U.K. presidency of the G8 and of the EU during 2005. Ministers from 20 countries and representatives from international bodies, business and non-governmental organizations participated in the Energy and Environment Ministerial Roundtable held in London on 15–16 March 2005. They identified not only key climate change goals, but also common ground relating to energy and environment policy, economic development and poverty eradication by improving the accessibility and affordability of modern energy services.⁴⁹ Much as Russian ratification depended on linkages to WTO talks, there are some indications that climate change after 2012 might be coupled to a broader development agenda.

Conclusion

The gap between current targets and the projected emissions means that a greater mitigation effort is needed. The IPCC's second assessment summarized the implications of continued emissions and the required effort as follows:

If net global anthropogenic emissions (i.e. anthropogenic sources minus anthropogenic sinks) were maintained at current levels (about 7 GtC/yr including emissions from fossil fuel

combustion, cement production and land-use change), they would lead to a nearly constant rate of increase in atmospheric concentrations for at least two centuries, reaching about 500 ppmv (approaching twice the pre-industrial concentration of 280 ppmv) by the end of the 21st century. Carbon cycle models show that immediate stabilization of the concentration of carbon dioxide at its present level could only be achieved through an immediate reduction in its emissions of 50–70% and further reductions thereafter.⁷

Developing countries — in particular the more rapidly industrializing ones like South Africa — will need to face up to their global responsibility. The more such efforts can be aligned with local plans for sustainable development, the more likely they will be implemented.

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